THURSDAY, AUGUST 25, 1881

PAPIN

Dr. Ernst Gerland's Life and Letters of Papin. (*Leibnizens' und Huygens' Briefwechsel mit Papin, nebst der Biographie Papin's,* von Dr. Ernst Gerland. Berlin, 1881.)

AT a time when Britons have just been celebrating the centenary of Stephenson a glance at the life and works of one who in a much more accurate sense was *the inventor* of the steam-engine may not be amiss. Denis Papin, whose life and letters now appear from the editorial pen of Dr. Ernst Gerland, was born at Blois in 1647. In 1661 or 1662 he proceeded to the study of medicine at the University of Angers, and, receiving his degree in 1669, he appears to have intended to settle down to a physician's life in that city. Why this course was not fulfilled is not known; but we find him in 1674 at Paris, where also he had made the acquaintance of Huygens, with whom he was engaged in experimenting with the newly-discovered air-pump, an account of which was published in that year at Paris under the title of "Expériences du Vuide." The *Philosophical Transactions* of our Royal Society for the following year (1675) were enriched by no fewer than five papers on the same subject by Huygens and Papin jointly. In Paris also Papin met Leibniz, who sojourned there from 1672 to 1676. His acquaintance with Leibniz was however interrupted, for, very shortly after the publication of his "Expériences," he crossed the Channel to England, led, as Boyle tells us, by some hope that here he might procure a situation accordant to his genius. In London he assisted Boyle in his laboratory and with his writings, and shortly afterwards introduced into the air-pump the further improvement of making it with double barrels, and replacing the turncock hitherto used by the two valves. A little later he produced another instrument, the condensing pump, and in 1680, on Boyle's nomination, he was admitted to the distinction of Fellowship in the Royal Society. That honour he repaid in the following year by communicating to the Society his famous invention of "A new Digester or Engine for Softening Bones," in which instrument—now so universally known—he applied as it seems for the first time the now common device of a safety-valve. For that year and the next he devoted himself to experiments with the digester and its various applications. Then he received an invitation to proceed to Venice to take part in the work of the Accademia di Scienze Filosofiche e Matematice, then newly founded, in imitation of the learned societies of Rome, Florence, Paris, and London. Here he appears to have remained nearly two years, and early in 1684 we find him back again in London, where, on April 2, he was elected by the Royal Society as their "temporary curator of experiments," at a salary of 30*l.* per annum. This was in the palmiest days of the young Society, when Newton, Boyle, Hooke, Hawkesbee, and many other famous spirits took the most active part in its proceedings, and Papin shared in the work of bringing their experiments, embracing a most miscellaneous range of subjects, before the Society. Amongst the discoveries of his own, of which Dr. Gerland gives a summary, in this way brought before the Royal Society, was the so-called Würtemberg siphon. He also partially anticipated Franklin in his discovery of the ebullition of water under reduced pressure at lowered temperatures, concerning which point he observes: "This shows that liquors being freed from an external pressure will make bubbles upon the score of the elastic particles lurking in their pores, as has been observed long ago by the Hon. Mr. R. Boyle. I do therefore believe that the vapours raised by heat in an exhausted glass will make a pressure, which is quickly taken off when we condense these vapours by putting the glass into cold water or ice." On another occasion Papin brought forward a model of a machine for raising water by pumps to a height, the pumps being worked by a water-wheel driven by the flow of a river. In November, 1687, this occupation came to an end by Papin resigning his post of curator on being appointed by the Landgrave of Hesse to be Professor of Mathematics at Marburg. Here the most active portion of his life began, to be continued when, in 1696, his place of residence was exchanged for Cassel. Here too began the correspondence with Huygens and with Leibniz, which forms the major part of the volume before us. By both of these great men he was highly esteemed. Huygens explained to him in 1690 his new theory of double refraction in a letter of considerable length. Leibniz wrote to Luca about Papin, referring to his ingenious inventions in the most enthusiastic terms. The correspondence with Leibniz went on almost unbroken until Papin's final return to England heart-broken and worn out. That with Huygens ended much earlier, being terminated by Huygens' premature decease in 1695. To Huygens in 1691 Papin writes from Cassel about a project he is undertaking for the Landgrave, to construct a ship on the plan suggested previously by Drebbel to move under water. In the same letter he mentions the production of fog or mist in the receiver of the air-pump, for which phenomenon Huygens, in replying, propounds an explanation. At the same date we find Papin busy with another invention, a *rotilis suctor,* which was nothing else than a centrifugal fan for supplying a blast for furnaces and for ventilating mines, which instrument he had the satisfaction of applying to a mine in Germany in 1699, and six years later he made the further improvements related in the *Philosophical Transactions* of that year. But his greater work was drawing on. In 1698 he writes to Leibniz that he is constructing a machine for raising water to a great height by the force of fire, and that by the success of his experiments he is persuaded that this force can be applied to many other more important ends. Leibniz replied forthwith with the inquiry whether his invention was based upon the principle of rarefaction; adding that he also had some ideas on the point. After two months Papin replies that he relies upon the principle of rarefaction produced by the condensation of steam, but that he proposes also to use the pressure exerted by the steam in expanding, "the power of which is not limited as is that of the suction" (of rarefaction). He also says that he has made a little model of a carriage which is propelled by this force, but that he fears difficulties for such carriages from the inequalities and sharp turns of ordinary high roads—difficulties which for water carriages do not exist. Leibniz's reply is only known from a summary of it scribbled in his own handwriting upon the back of Papin's letter. He first congratulates Papin on having set himself to this work; expresses his fears lest the direct pressure of expanding steam should produce explosions; and then suggests, "pour faciliter le chariotage," an idea of his own (derived, he says, from the air-pump), that the steam which is to exert pressure should be introduced into a cylinder into which is fitted a second one, after the manner in which our modern gasometers fit into their cylindrical pits, the whole being rendered steam-tight by mercury. Papin, replying in August, announces that his machine has raised water to the height of 70 feet. He only half approves Leibniz's suggestion on account of the probable friction between the internal cylinders. To this Leibniz retorts that while the friction increases with the diameter of the piston of a pump, the pressure increases as the square of the diameter. The matter seems to have dropped at this stage for three years. In 1702 Papin, still at Cassel, announces to Leibniz that he has invented a steam *ballista*, "an invention to facilitate the capture of the strongest places," which "will reduce France to make most promptly a durable peace!" This invention was a cylinder 5 inches in diameter filled with a piston connected to pivoted lever, which on the descent of the piston on the condensing of the steam below it would project a stone weighing 2 lbs. to a distance of 40 feet. (A similar ballista, unknown to Papin, had been suggested by von Guéricke, in 1672, in his *Experimenta Nova.*)

Early in January, 1705, Leibniz sent to Papin a sketch of Savery's engine for raising water. This set Papin with renewed vigour to work, besides stimulating to emulation the breast of his patron, the Landgrave of Cassel. After some consideration he pronounced in another letter to Leibniz that he would surpass Savery's invention. He related how he had thought it best not to let the steam act directly against the surface of the water (as in Savery's machine), but that the pressure of the steam should be imparted to the water through the intermediation of a *piston* whose surface, becoming hot, would not produce condensation: and he added that experiment had proved the conjecture to be sound. His great difficulty now was, not to make pistons fit accurately, but to construct tubes sufficiently strong to bear the pressure of such columns of water as he wished to raise. Leibniz congratulated him when replying in August, and advised him not to try to force water high, but rather to lift it by a series of pumps, each drawing 30 feet, a suggestion which Papin on his part rebutted by observing that one force-pump driving water 500 feet high was more economical than ten pumps, each raising the water 50 feet. He further lets Leibniz know that he hopes to do away with the delay of letting the cylinder of his engine cool between each stroke (the very first of the improvements subsequently made by Watt), and that he has some ideas about the transmission of power to a distance, with which problem however he thinks it useless to concern himself, "because by means of the heat-engine one can produce, everywhere where one will, so much power, and so cheaply, that it would be a superfluous expense to carry it elsewhere." Strange commentary, indeed, on the present eager strife of inventors to supersede steam by the electric transmission of power! On October 19 he writes again that he is almost satisfied with his engine, which, though having but one cylinder and two valves, yet furnishes a continuous jet, surpassing Savery's machine, which had two pressure-vessels and four valves: he is only waiting the Landgrave's orders as to how he shall apply his engine to drive a mill. On the last day of the year 1705 he declares to Leibniz his intention of propelling vessels by steam, as he is persuaded that by this means one could have vessels which would follow their course correctly in spite of tempests and adverse winds. At this idea he laboured diligently for the next two years—in fact, so long as he continued to remain at Cassel—his devotion to the object in hand being remitted only for the sake of his correspondence and for the work of publishing his treatise, the "Ars Nova," in which his high-pressure boiler and its applications are described. It was towards the close of this time that (on February 4, 1707) he communicated to Leibniz the first suggestion of a hot-air engine, afterwards realised by Stirling and Ericssen. He was now preparing to leave Cassel, where the patronage of the Landgrave had grown on the one hand slack, on the other irksome, in order to regain the more congenial atmosphere of London and of the Royal Society. He strained every nerve and spent all his little resources to accomplish the building of the steam-propelled boat by which his return to England was to be made famous. He was certain that by this means two men on board his boat might do more than a hundred rowers could. In July and August of that year he made diligent efforts to obtain permission to descend the river *viâ* Münden and Bremen into the Veser, permission which was finally granted by the Elector of Hanover, in spite of the monopoly possessed by the guild of boatmen of Münden to pass boats from the Fulde into the Veser. With a boatman of Münden as captain, he sailed from Cassel on September 24, 1707, with his family. At Münden however the guild of boatmen asserted their privileges, the magistrates pronounced the boat confiscated, and a handsome offer of ransom was rejected. Papin pushed forward despairingly for England; only to find himself almost unknown and friendless. The old generation was fast passing away. For two or three years he continued his mechanical inventions, and several times applied through Sloane for a grant of money from the Royal Society to aid him in his work, but in vain. Misunderstanding and misery followed apace. The inventions on which he relied for fame and position were passed by unnoticed. In the loss of his ship he had made shipwreck of his life's hopes. He died in London, probably, in the early half of the year 1712, but in such obscurity that neither place nor date is with any certainty known.

Dr. Gerland appears to have spared no pains in collecting the scattered facts of Papin's life and work from which to build the volume whose contents we have endeavoured to make known to English readers. We congratulate him on his success, and trust that his efforts will be further rewarded by the discovery of the facts still required to fill the *lacunæ* in the career of this remarkable man. The light which the publication of the correspondence between Leibniz and Papin throws upon the relation between two prominent figures amongst men of science at that time is by no means the least interesting feature of the work; and we must henceforth place

Leibniz amongst the worthies to whom the credit of improvements in the steam-engine is given. The one common feature that runs through the many different types of steam-engine is the piston working within a cylinder. No engine before Papin's time was adapted for any useful purpose except for raising water, and none had a piston in a cylinder. No engine since Papin's time of the thousand varied types has been devoid of this feature. But the very feature which Papin introduced, and on the introduction of which his claim to be called *the* inventor of the steam-engine has been founded, was, as we now know, the suggestion of another mind. We owe the application of the piston-principle in the steam-engine, not to Papin, but to Leibniz.

CHEMISTRY OF THE FARM

The Chemistry of the Farm. By R. Warington, F.C.S. Pp. xiii. and 128. (London: Bradbury, Agnew, and Co., 1881.)

THE chapters of this little handbook appeared originally in detached portions in the *Agricultural Gazette*. They have been revised, and are now issued in a convenient and compact form. A well-ordered manual of agricultural chemistry, clearly written and perfectly abreast of recent advances in the sciences underlying the farming art, has long been wanted. So far as the limits of its size and scope allow, Mr. Warington's volume fulfils our expectations. It is a satisfaction which is seldom afforded us to read a book on agricultural chemistry written by a true chemist trained in laboratory work and versed in the progress made through English and foreign researches. The applications of chemistry to agriculture are manifold, and cannot be grasped by chemists who do not combine with their chemistry a competent knowledge of vegetable and animal physiology and of mineralogy. Yet to learn or to teach the Chemistry of the Farm without a knowledge even of the foundations of chemical science is commonly attempted, though it can never succeed in any true sense. And we quite agree with Mr. Warington that a wider range of scientific knowledge than this is needed even for the student of agricultural chemistry—much more then for the teacher. To talk about this applied science to persons without previous scientific knowledge, and to look for satisfactory results, is to expect a plant unfortunately destitute of roots to blossom and bear fruit.

We think then that Mr. Warington's handbook is valuable on account not only of the knowledge with which its subject is handled, but also on account of the spirit with which that subject is approached. That a new work on agricultural chemistry was sorely needed does not admit of question. In France and in Germany the educational literature of this subject includes many excellent works which have no English counterparts. Johnston's treatise, full as it is of valuable observations, is too thoroughly out of date in method as well as in matter to admit of satisfactory revision; much the same judgment must be passed on Anderson's "Agricultural Chemistry," now twenty years old and out of print. Even if Georges Ville's work on Manures included (which it is far from doing) anything like the whole domain of the Chemistry of the Farm, it is about as unsafe and misleading a book as could be put into the hands of a student. Mr. Warington has given us, in fact, not all we want, but a good bit of it. He has used, and that judiciously, both German and English text-books, researches, and memoirs, and has put the main facts they enounce into a neat form, so as to be "understanded of the people." The two capital text-books of Emil Wolff have been laid under contribution by Mr. Warington; while the chief results of some of the matchless Rothamsted Memoirs by Lawes and Gilbert have been skilfully introduced into his pages. Of the contents of these it is now perhaps time to say a few words. In five chapters the growth, the food, the nutrition, and the products of farm crops are discussed; in another five, animal growth, food, nutrition, and products. Of the diverse origins and properties of soils but little is said; as to the utilisation of urban sewage, nothing. And we should have been glad to have found fuller accounts of many subjects which are but lightly touched upon in these pages. But the difficulty of treating so vast and complex a subject intelligibly in so few pages makes us surprised, not that some things are omitted from, but that such a large number of things are included in, this little book. Some facts and figures which the author would doubtless have liked to introduce have been kept out of his pages by the absolute necessity of finding room for numbers and arguments of primary importance. For instance, it would have been unwise to have curtailed the space bestowed upon the "Digestibility of Foods" and the "Albuminoid Ratio."

In reading through this handbook carefully we have been unable to discover more than a very few statements which we cannot completely endorse; in fact the majority of such alterations as we would suggest would be of form rather than of substance. We cannot, however, refrain from expressing our regret that the percentages of albuminoids in potatoes and roots as given in the table on p. 72 should be the old erroneous figures condemned on the very next page as greatly in excess of the truth. Mr. Warington has however so thoroughly recognised the importance of the discrimination between albuminoid and non-albuminoid nitrogen that we must attribute the inclusion of the incorrect figures in his tables to the difficulty of constructing a complete series of analyses comparable with one another in this particular of the percentage of true albuminoids.

A. H. CHURCH

OUR BOOK SHELF

A Handbook of the Vertebrate Fauna of Yorkshire. Being a Catalogue of British Mammals, Birds, Reptiles, Amphibians, and Fishes, showing what species are or have within historical periods been found in the County. By Wm. Eagle Clarke and Wm. Denison Roebuck. (London: Reeve and Co., 1881.)

THIS little volume is dedicated to the President-Elect of the British Association, and most seasonably makes its appearance on the eve of the meeting of that Association in the city and county of its origin, when it will celebrate the completion of the first fifty years of its existence. Its object is the enumeration of those animals with a vertebral column which either are or have been found in Yorkshire, and the careful definition of their faunistic position and geographical distribution within the county. It would appear that there has never been a list of the mammals, birds, or fishes of the county of York published, and in this respect it presents a striking contrast with its neighbouring counties of Norfolk, Northumberland, and